8. Ground Water Protection Management Program

Richard A. Brown
Richard G. Blake

Introduction

LLNL's Ground Water Protection Management Program is a multifaceted effort to eliminate or minimize adverse impacts of Laboratory operations on ground water, determine the extent and understand the impact of past activities, remediate adversely affected areas, and monitor current operations.

DOE Order 5400.1 requires all DOE facilities to prepare a plan that describes the site's ground water regime; describes programs to monitor the ground water and monitor and control potential sources of ground water contamination; and describes areas of known contamination and remediation activities. Ground water surveillance and compliance monitoring at the Livermore site, in the Livermore Valley, and at Site 300 in the Altamont Hills is carried out as required by DOE Orders, by written agreement with the California Environmental Protection Agency (Cal-EPA), and by permits and other requirements from the California Regional Water Control Boards (RWQCBs). This monitoring can be divided into two general types: that carried out under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and other surveillance monitoring driven mainly by DOE Order 5400.1. Much of the ground water monitoring at the Livermore site and Site 300 is carried out under CERCLA restoration efforts. This monitoring is fully described in documents issued by the Site 300 Restoration Project and Livermore site Ground Water Project (see Appendix A).

Ground Water Regime

The ground water regime at the Livermore site and at Site 300 is described in the following sections.

Livermore Site

Physiographic Setting

The Livermore Valley, which is the most prominent valley within the Diablo Range, is an east-west trending structural and topographic trough bounded on the west by Pleasanton Ridge and on the east by the Altamont Hills. The valley floor is covered by alluvial, lake, and swamp deposits consisting of gravels, sands, silts, and clays with an average thickness of about 100 meters. The valley is approximately 25 kilometers long and averages 11 kilometers in width. The valley floor is 220 meters at its highest elevation along the eastern margin and gradually dips to 92 meters at the southwest corner. The major streams dissecting the Livermore Valley are Arroyo del Valle and Arroyo Mocho, which drain the southern highlands and flow only during the rainy season.

Livermore Valley Ground Water Basin

The Livermore Valley Ground Water Basin lies within the Diablo Range, which reaches a maximum elevation of 1,160 meters in the tributary watershed. Including the uplands and valley floor, the ground water basin encompasses 17,000 hectares. The prominent streams, all of which are ephemeral, include Arroyo del Valle, Arroyo Las Positas, Arroyo Seco, Arroyo Mocho, Alamo Creek, South San Ramon Creek, and Tassajara Creek. Arroyo del Valle and Arroyo Mocho drain the largest areas and are the largest streams. These streams all flow toward the valley floor and then westward until they converge at Arroyo de la Laguna, which flows southward out of the valley into the Sunol Valley Ground Water Basin.

The Livermore Valley ground water system can be described as a sequence of semiconfined aquifers. Ground water moves downslope from the perimeter (the valley uplands) toward the longitudinal axis of the valley. It then flows in a generally westward direction toward the southwest portion of the basin. From this point, the ground water flows south into the Sunol Valley Ground Water Basin. However, since 1945, heavy draft from the area has eliminated any subsurface outflow from the Livermore Valley Ground Water Basin.

The Livermore Formation, with an average thickness of about 1,000 meters and an area of approximately 250 square kilometers, has an available storage capacity significantly greater than that of the overlying alluvium, which averages only about one-tenth the thickness. However, the alluvium is considerably more permeable and is, therefore, the principal water-producing formation for most of the valley (San Francisco RWQCB 1982). The largest quantities of ground water are produced in the central and western portions of the Livermore Valley, where the valley fill is thickest.

The quality of ground water in the Livermore Valley Ground Water Basin is generally a reflection of the surface water that recharges the aquifers. The chemical character ranges from an excellent quality sodium, magnesium, or calcium bicarbonate to a poor quality sodium chloride water. In the eastern part of the valley, the poor quality sodium chloride ground water is indicative of the recharge waters from Altamont Creek, which drains the marine sediments to the east of the valley. High concentrations of naturally occurring dissolved minerals, especially boron, in the eastern part of the valley render the ground water unsuitable for irrigation purposes. Infiltration of wastewater or fertilizers applied to crop lands causes locally elevated levels of nitrates (San Francisco Bay RWQCB 1982). Areas with rapid infiltration rates are limited to the larger stream courses of Arroyo del Valle, Arroyo Mocho, and, to a lesser extent, Arroyo Las Positas.

Surface Drainage

The natural drainage at the Livermore site has been altered by construction activities so that the current northwest flow of Arroyo Seco and the north-then-west flow of Arroyo Las Positas do not represent historical flow paths. About 1.6 kilometers to the west of the Livermore site, Arroyo Seco merges with Arroyo Las Positas, which continues to the west to eventually merge with Arroyo Mocho. An abandoned stream channel is visible on air-photo maps of the site east of the present alignment of Arroyo Seco (Carpenter 1984). A Central Drainage Basin for storm water diversion and flood control was constructed near Building 551 and collects surface water runoff from the Arroyo Las Positas drainage. This was lined in 1990 to prevent infiltration in this area. The gentle 0.5°-to-1° northwest slope of the ground surface (not composed of drainage ways) suggests Holocene deposition by streams flowing northwest from the south and east. Actual ground elevations range from 170 to 200 meters above mean sea level.

Hydrogeology

Sediment types at the Livermore site can be grouped into four categories, based on dominant particle size by volume: clay, silt, sand, and gravel. The hydrostratigraphic units of concern at the site are part of the Quaternary alluvial deposits of the upper Livermore member of the Livermore Formation. These strata comprise the upper section of strata at the site and vary from approximately 60 meters thick on the eastern part of the site to 120 meters thick on the west. Ground water flow is primarily in sand and gravel lenses and channels, bounded by the less permeable clay and silt.

Based on borehole lithologic data, a series of buried sand and gravel-filled stream channels have been identified at the site. The sand and gravel deposits, which are highly permeable, are present in narrow bands at the site and are interpreted as braided stream deposits, similar to strata deposited by the present day Arroyo Mocho. Sand and gravel deposits do not exceed about 30% of the section anywhere at the Livermore site.

The permeable sediments of the Upper Livermore Formation at the Livermore site are vertically separated by the horizontally extensive, low permeability silt and clay of the Lower Member of the Livermore Formation, which comprise a regional confining layer.

The depth to ground water ranges from over 40 meters in the southeast corner of the site to 10 meters in the northwest and 12 meters in the northeast corners (Thorpe et al. 1990). Ground water levels respond to climate and resource use.

Decreases in ground water use from the 1960s to 1985 caused the water table to rise. Heavy rains caused a rise in 1986, 1993, and 1994, and droughts caused a decline in 1987 through 1991.

Ground water recharge at the Livermore site primarily consists of controlled releases from the South Bay Aqueduct and direct rainfall. Recharge enters primarily through the arroyos and, until its lining in 1990, the Drainage Retention Basin.

Ground water flow at the Livermore site is generally westward. The gradient is steepest near the northeast (about 0.15 meter / meter) and southeast corners of the site and decreases to about 0.002 meter / meter west of the site. The downward vertical gradient at the Livermore site ranges from 0.25 meter / meter on the east side to 0.3 meter / meter on the west side.

Subsurface Migration Off Site

The conceptual model presented in the *CERCLA Remedial Investigation Report for the LLNL Livermore Site* (Thorpe et al. 1990) suggests that ground water generally flows towards two destinations from the Livermore site. Ground water from the north half flows west and northwest and eventually discharges to Arroyo Las Positas near First Street in Livermore, about two kilometers northwest of the Livermore site. Ground water from the southern half flows generally westward toward the gap between the Mocho I and Mocho II subbasins, about two kilometers west of the Livermore site. Ground water velocities at the Livermore site average about 15 to 20 meters (49 to 66 feet) per year. In the area of the gap, the magnitude and direction of ground water flow is uncertain; investigations are under way to determine if ground water from the Livermore site (Mocho I subbasin) migrates westward into the Mocho II subbasin, where several City of Livermore water-supply wells are located.

Site 300

Geology

The topography of Site 300 is much more irregular than that of the Livermore site; a series of steep hills and ridges is oriented along a generally northwest-southeast trend and is separated by intervening ravines. The elevation ranges from approximately 150 meters above sea level at the southeast corner of the site to approximately 538 meters in the northwestern portion.

The Altamont Hills, in which Site 300 is located, are part of the Coast Range Province and separate the Livermore Valley to the west from the San Joaquin Valley to the east. The southern boundary of the Altamont Hills is locally well defined by the abrupt rise in the terrain as the Franciscan Complex core of the Diablo Range emerges south of the Tesla Fault.

The Neroly Formation is the principal hydrologic unit within Site 300 and has been the focus of the detailed geologic and hydrogeologic studies conducted during recent years (Webster-Scholten 1994). The total thickness of the Neroly Formation beneath Site 300 appears to vary from about 140 meters to more than 150 meters. The lower portion of the section is thicker beneath the southerly part of Site 300, whereas the upper portion is thickest beneath the northeastern portion of Site 300.

The active floodplain of Corral Hollow Creek lies along the southern boundary of Site 300, underlying portions of the western and eastern General Services Area. The floodplain also makes small incursions into Site 300 in the vicinity of closed landfill Pit 6. Floodplain alluvium consists primarily of coarse cobble and boulder-bearing gravel derived from Franciscan sources, with lenses and local cappings of sandy silt and silty clay.

The bedrock sequence within Site 300 has been slightly deformed into several gentle, low-amplitude folds. The locations and characteristics of these folds, in combination with the regional fault and fracture patterns, may locally influence ground water flow within the site and have therefore been studied as part of LLNL's CERCLA investigations.

Hydrogeology

Gently dipping sedimentary bedrock dissected by steep ravines generally underlies Site 300. The bedrock is made up primarily of interbedded sandstone, siltstone, and claystone. Most ground water occurs in the Miocene Neroly Formation upper blue sandstone and lower blue sandstone aquifers. Significant ground water is also locally present in permeable Quaternary alluvium valley fill. Much less ground water is present in the Plio-Pleistocene nonmarine unit, where it occurs as perched water-bearing zones beneath hilltops in the Building 833 and Building 834 areas, and more extensively in the High Explosives (HE) Process Area. The perched water-bearing zone at Building 833 is ephemeral. Fine-grained siltstone and claystone interbeds act as aquitards, confining layers, or perching horizons. Ground water is present under confined conditions in parts of the deeper bedrock aquifers, but is generally unconfined elsewhere.

Recharge occurs predominantly in locations where saturated alluvial valley fill is in contact with underlying permeable bedrock, or where bedrock strata crop out because of structure or topography. Local recharge also occurs on hilltops, thus creating the perched water-bearing zones at Buildings 833 and 834. Low rainfall, high evapotranspiration, steep topography, and intervening aquitards generally preclude direct vertical recharge of the bedrock aquifers.

Ground water flow in most aquifers follows the attitude of the bedrock. In the northwest part of Site 300 (north of the east-west trending Patterson anticline), bedrock ground water flows generally northeast, except where it is locally influenced by ground water in alluvium-filled ravines. In the southern half of the site, bedrock ground water flows roughly south-southeast, approximately coincident with the attitude of bedrock strata.

At Site 300, some ground water bodies are regional in extent, such as the Neroly lower sandstone and Cierbo aquifers; others occur as isolated, discontinuous, water-bearing zones underlying hilltops. Ground water is also locally present in alluvial terrace deposits and valley fill.

Ground water in the Neroly lower sandstone aquifer is unconfined in much of the northwestern part of Site 300. In the southern HE Process Area, several flowing artesian wells are present. The elevation of the potentiometric surface in some flowing wells is about 5 meters above ground level, or about 1 meter higher than in the shallower Neroly upper sandstone aquifer.

The Cierbo Formation is saturated beneath Doall Ravine, the Building 851 Area, and the southern part of the East Firing Area. This formation is unsaturated or does not otherwise yield water to wells in other parts of the East and West Firing Areas; this may be the result of swelling clays in pore spaces.

Ground Water Monitoring

Several ground water monitoring programs are in place at the two Laboratory sites and in the surrounding area; their purposes constitute their primary differences. One is to determine impacts from current and ongoing activities; another is determine if there is contamination from past practices and to remediate it.

Livermore-Site Ground Water Monitoring

Surveillance monitoring carried on in the Livermore Valley and on the Livermore site includes both surface and ground water monitoring (see Chapters 6 and 7 of this report). Surface water monitoring is important for ground water protection because contaminants from surface water can reach ground water. Surface water monitoring at the Livermore site includes storm water monitoring and monitoring of nearby surface and domestic waters for radioactive constituents. The storm water monitoring network may be especially crucial in times of significant storm events that might transport pollutants into the permeable sediments at the bottoms of the arroyos, particularly Arroyo Seco. (Chapter 6 contains details of all surface water monitoring networks.)

The ground water monitoring network that supports the Livermore-site remediation effort was initially established to identify and delineate any ground water contamination that may have originated from the Livermore site. Over the years, monitoring has included a good spatial sampling of the entire site plus the off-site areas related to contaminant plumes that have migrated from the site. In every case, wells were drilled to establish a clean zone beyond the limits of measurable contaminants, both vertically and horizontally. Boreholes and monitoring wells were also placed to establish the sources of the contaminants. Over 400 wells are in the regularly monitored network. **Figure 8-1** shows all monitoring wells, piezometers, extraction wells, and treatment facilities as of December 1994.

When a well is initially installed, a comprehensive suite of analyses is performed to establish the baseline conditions for ground water from that well. Follow-on analyses provide data on remedial activities so sampling can be limited to analytes of concern. The primary ground water contaminants at both the Livermore site and Site 300 are volatile organic compounds (VOCs) and tritium. While these comprise the main analytes of concern, analyses for chromium, physical parameters, and pH are also requested on many samples.

Ground water samples are collected quarterly for 18 months from newly installed monitoring wells and piezometers. This sampling schedule may be changed as the distribution of contaminants in ground water changes. The sampling frequency is determined by evaluating the overall and recent (past 18 months) histories of each well. Wells exhibiting little change [<10 parts per billion (ppb) per year] will be sampled annually, wells exhibiting moderate change (>10 ppb and <30 ppb per year) will be sampled semiannually, and wells showing large changes (>30 ppb per year) will be sampled quarterly.

LLNL has designed a surveillance monitoring program to detect possible releases from the mixed-waste storage areas in the southeastern portion of LLNL. This program consists of four background and four downgradient monitoring wells and is being implemented in 1995; these wells were chosen to monitor the uppermost aquifers within that area. First-year monitoring efforts will be used to establish baseline conditions for future monitoring. This surveillance monitoring effort will be reported in the *Environmental Report for 1995*.

This surveillance monitoring program will be reevaluated on an ongoing basis to identify areas of potential concern that may warrant further monitoring (see Chapter 10, *Environmental Monitoring Plan*, Tate et al. 1995, for further details).

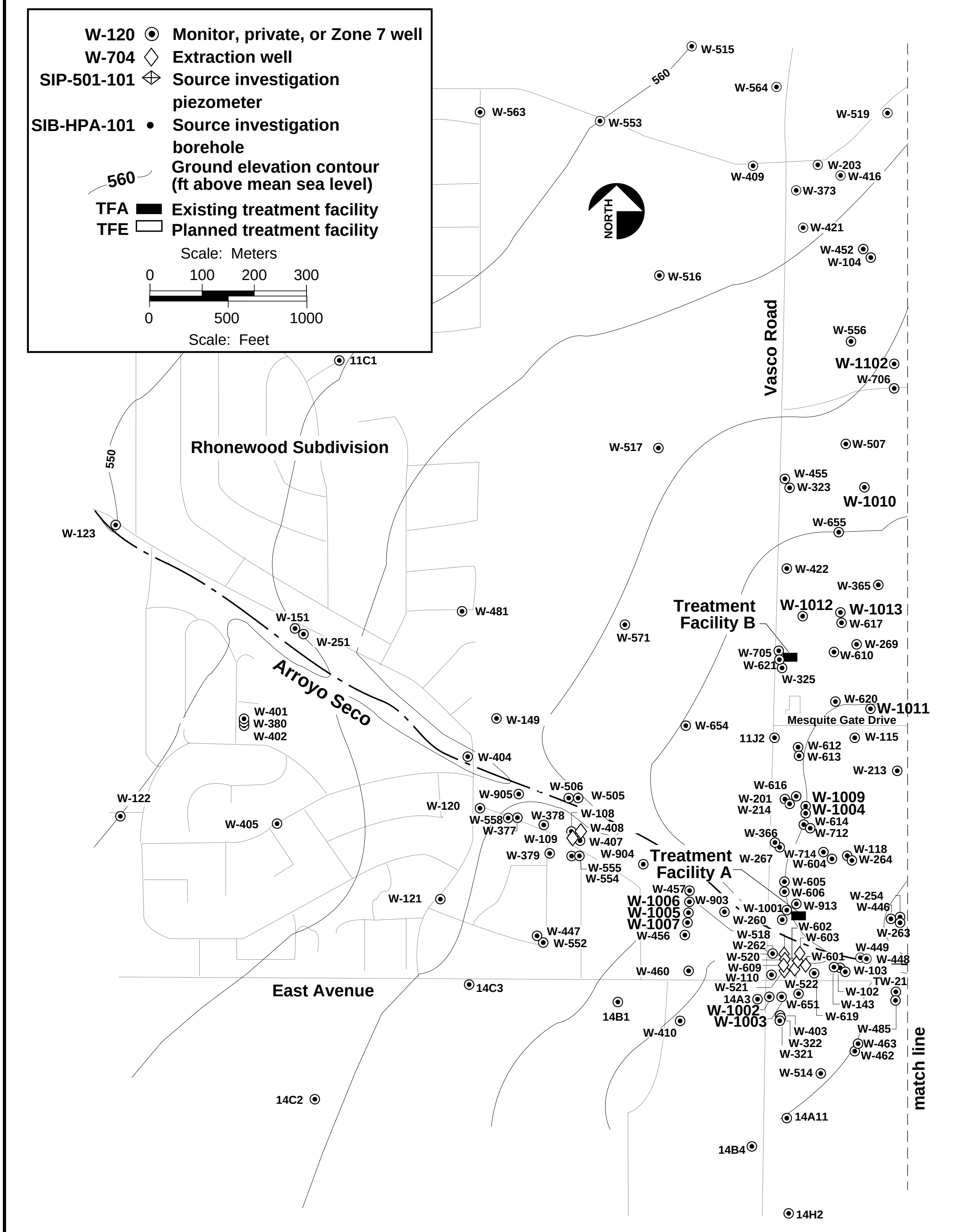

Figure 8-1. Livermore site location map for monitor wells, piezometers, extraction wells, and treatment facilities, December 1994.

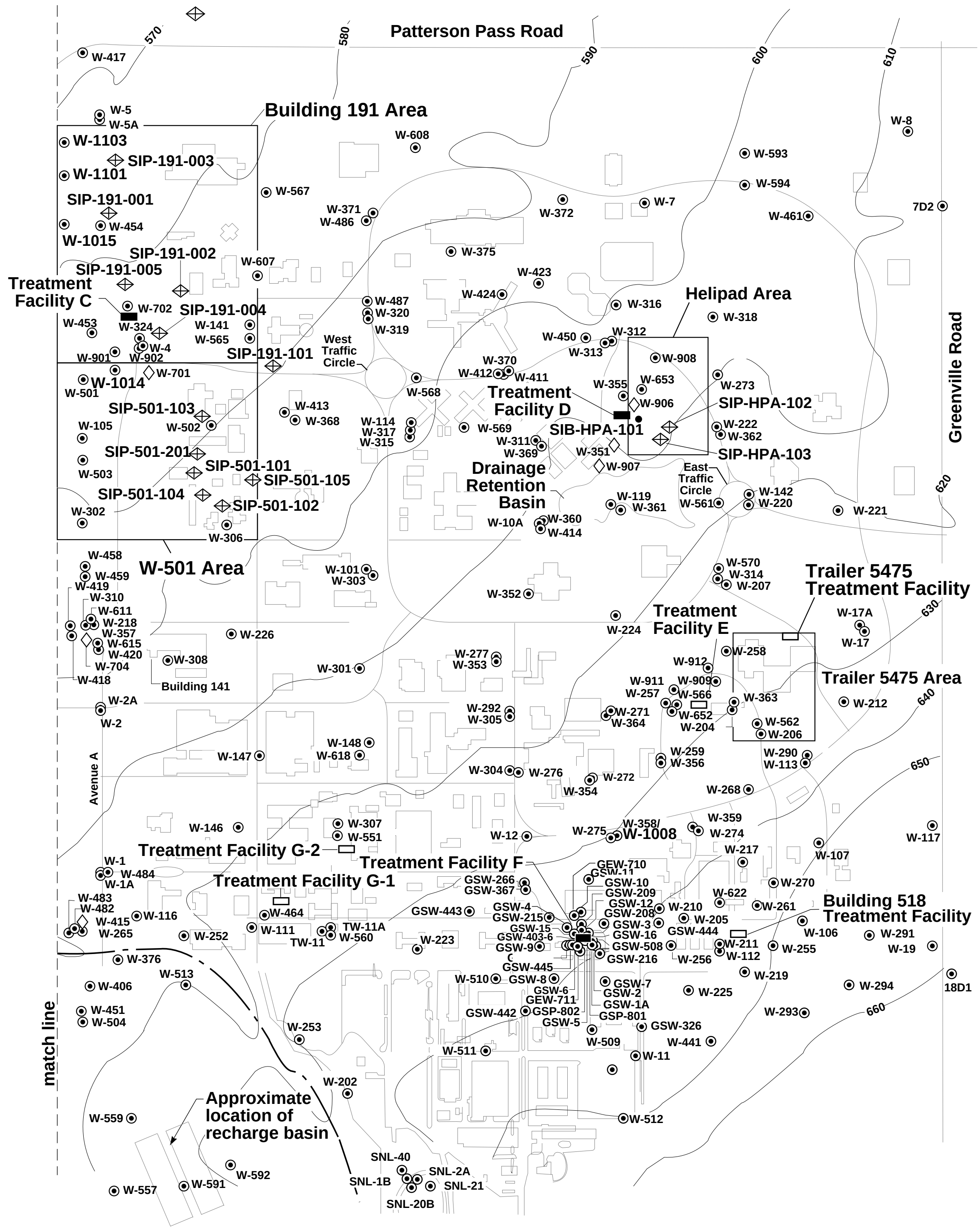

Figure 8-1. (continued).

Monitoring the ground water at any significant distance from the Livermore site is not required because of the slow ground water velocities. Tritium surveillance monitoring of Livermore Valley ground water-supply wells downgradient from LLNL to date has not detected significant migration of tritiated waters (see Chapter 7 for further information).

Pump-and-treat remediation is under way at several locations on the Livermore site (Hoffman et al. 1995). Five ground water treatment facilities are presently operational, and four additional facilities are planned (**Figure 8-1**). Monitoring of the extracted ground water and the capture area surrounding the extraction wells is done by measuring ground water level drawdown in nearby monitoring wells and piezometers. Particular attention is paid to the ground water cone of depression surrounding the pumping wells and the changes in contaminant concentrations resulting from the pump-and-treat effort (see Chapters 2 and 13).

Site 300 Ground Water Monitoring Program

Water monitoring at Site 300 can be divided into three types—surveillance, compliance, and remedial action. As with the Livermore site, the purpose of the remedial monitoring is to support the investigations and restoration activities associated with CERCLA compliance and cleanup.

As with remedial monitoring at the Livermore site, when initially drilled, a general suite of analyses is performed on each new monitoring well. The results of these analyses, as well as historical information concerning suspected contaminants in the area, are used to determine the continuing monitoring program. Wells without measurable contaminants and located in areas with no history of contaminant usage are sampled at least once a year. Wells in areas with known contaminants but with generally stable conditions are sampled at least twice a year. In regions where significant changes in contaminant concentrations are either observed or predicted (e.g., at the leading edge of the plume), quarterly sampling has been established. The depth to ground water is also measured quarterly unless special circumstances make it impractical to measure a particular well.

The surveillance monitoring program supports 35 ground water wells—23 on-site, including a drinking water-supply well, and 12 off-site—and two springs (see **Figure 7-2** in Chapter 7). Analytes to be monitored are chosen in accordance with current understanding of the ground water quality in the area and to determine the impact, if any, of LLNL operations at the site. The wells are currently sampled primarily for metals, radioactivity, and organic compounds. Details of this network and data for 1994 can be found in Chapter 7 of this report.

The compliance monitoring program ensures that LLNL meets its sampling, analysis, and reporting requirements, which are spelled out in permits and state and federal regulations (other than CERCLA requirements). Currently, the monitoring program is designed to meet the requirements of the closure and post-closure plans for landfill Pits 1 and 7 (Rogers / Pacific Corporation 1990), Waste Discharge Requirements (WDR) Order No. 85-188, and WDR Order No. 93-100. Details of this network and results for 1994 can be found in Chapter 7 of this report.

Areas of Contamination

The areas of contamination at the Livermore site and Site 300 are discussed below.

Livermore Site

The Livermore site is on the National Priority List for sites requiring environmental restoration in accordance with CERCLA and the Superfund Amendments and Reauthorization Act. In light of this, extensive investigations have been performed to identify contamination from past practices that has affected or could affect the ground water underlying the Livermore site. Detailed descriptions of these findings are available in the *CERCLA Remedial Investigation Report for the LLNL Livermore Site* (Thorpe et al. 1990) and in the *CERCLA Feasibility Study Report for Lawrence Livermore National Laboratory Livermore Site* (Isherwood et al. 1990). Additionally, Ground Water Project (GWP) progress reports were issued monthly, quarterly, and annually by DOE / LLNL in 1994 (see Chapter 2 for additional information). The *Record of Decision for Lawrence Livermore National Laboratory Livermore Site* (Ziagos 1992) became effective on August 5, 1992. This document presents the selected remedial actions for the LLNL Livermore site and was agreed upon by the EPA, San Francisco Bay RWQCB, and California Department of Toxic Substances Control (DTSC).

Currently VOCs, predominantly trichloroethene (TCE) and tetrachloroethene (PCE), exist in the ground water beneath about 85% of the Livermore site in relatively low concentrations. The contamination is believed to have started when the site was used as a Naval maintenance base during World War II. The calculated total volume of undiluted VOCs is about 800 liters; Treatment Facilities A, B, C, and D have removed a total of nearly 40 liters of those undiluted VOCs from the on-site ground water since the startup of the facilities (Hoffman et al. 1995). The VOCs are found in ground water plumes varying from 1 to 30 meters thick, but seldom found at depths greater than 70 meters. During 1994, the highest measured ground water concentrations of VOCs (excluding fuel hydrocarbons) were between 1–5 parts per million (ppm) of TCE found in under 2% of the over 400 wells; PCE concentrations did not exceed 1 ppm during 1994. The isoconcentration contours for total VOCs as of December 1994 are shown in **Figure 8-2**.

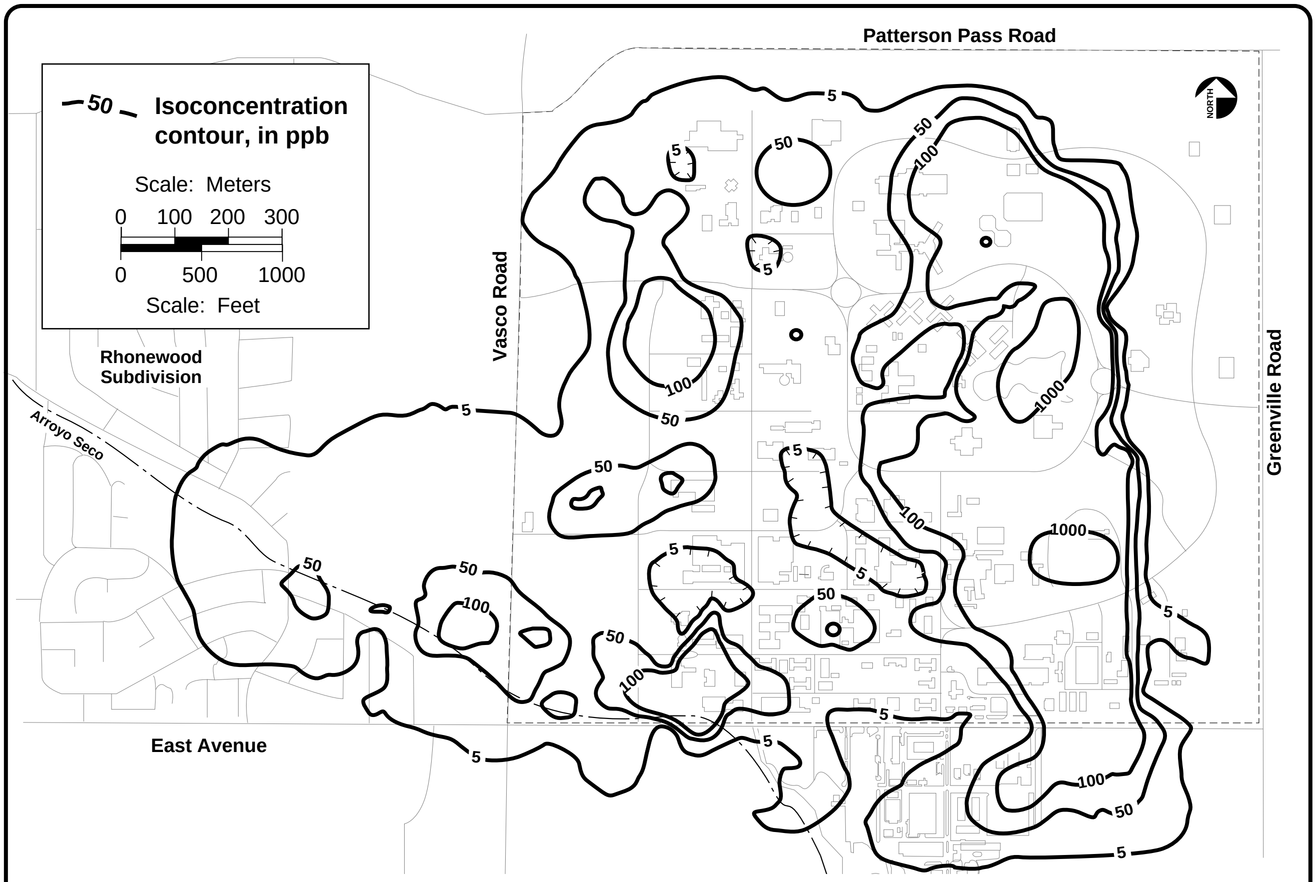

Figure 8-2. Total VOC isoconcentration contour map, LLNL in 1994.

The concentration of TCE in the unsaturated sediment is receiving special attention in two specific areas. Near Building 518, the TCE concentration reached a maximum of about 6 ppm at a depth of 7 meters. This TCE probably originated from surface spills or leaking drums in the post-Navy operations era. The area surrounding Trailer 5475 was formerly used for landfills and surface impoundments (these areas were excavated and restored in 1983–1985). Total VOC concentrations of up to 5 ppm are found in the unsaturated sediments in this area. Treatment facilities are planned for both of these areas (see Chapter 2).

Fuel hydrocarbon contamination is isolated to the area affected by a 66,000-liter leaded gasoline spill that occurred during the U.S. Navy era and subsequent LLNL operation. The fuel tank was removed from service and subsequently abandoned in place in 1979. **Figure 8-3** shows the extent of the contamination after remediation efforts during 1993 and 1994 . By December 1994, Treatment Facility F is estimated to have removed nearly half of the total estimated quantity of the gasoline spill (Hoffman, et al. 1994; 1995).

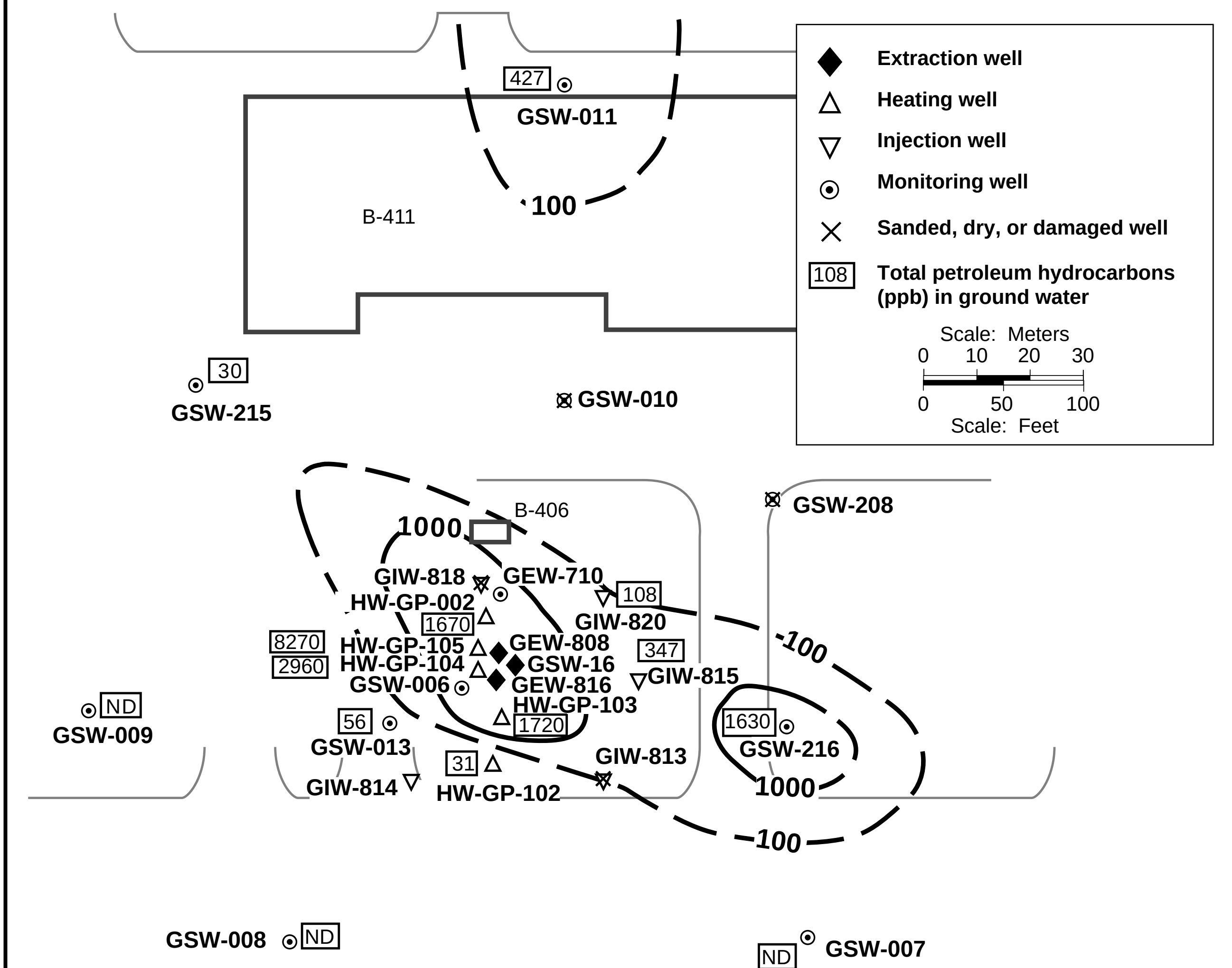

Figure 8-3. Total fuel petroleum hydrocarbon ground water concentrations (ppb) in the upper and lower steam zones, LLNL Gasoline Spill Area.

Tritium above the maximum contaminant level (MCL) of 740 Bq/L (20,000 pCi/L) is found in only one well (in the Building 292 area). However, tritium is found at levels considered elevated at several locations during 1994, mostly around Building 292 and Trailer 5475 (**Figure 8-4**). These two areas have unsaturated sediments with tritium concentrations that are also elevated. The source for the Building 292 contamination was a retention tank that leaked during the period that the facility housed the Rotating Target Neutron Source (information about release of tritium to air from this source is provided in Chapter 4, Air Monitoring). In the Trailer 5475 area, the source of the tritium is believed to be leakage from a lined solar evaporation pond used in the 1950s and 1960s.

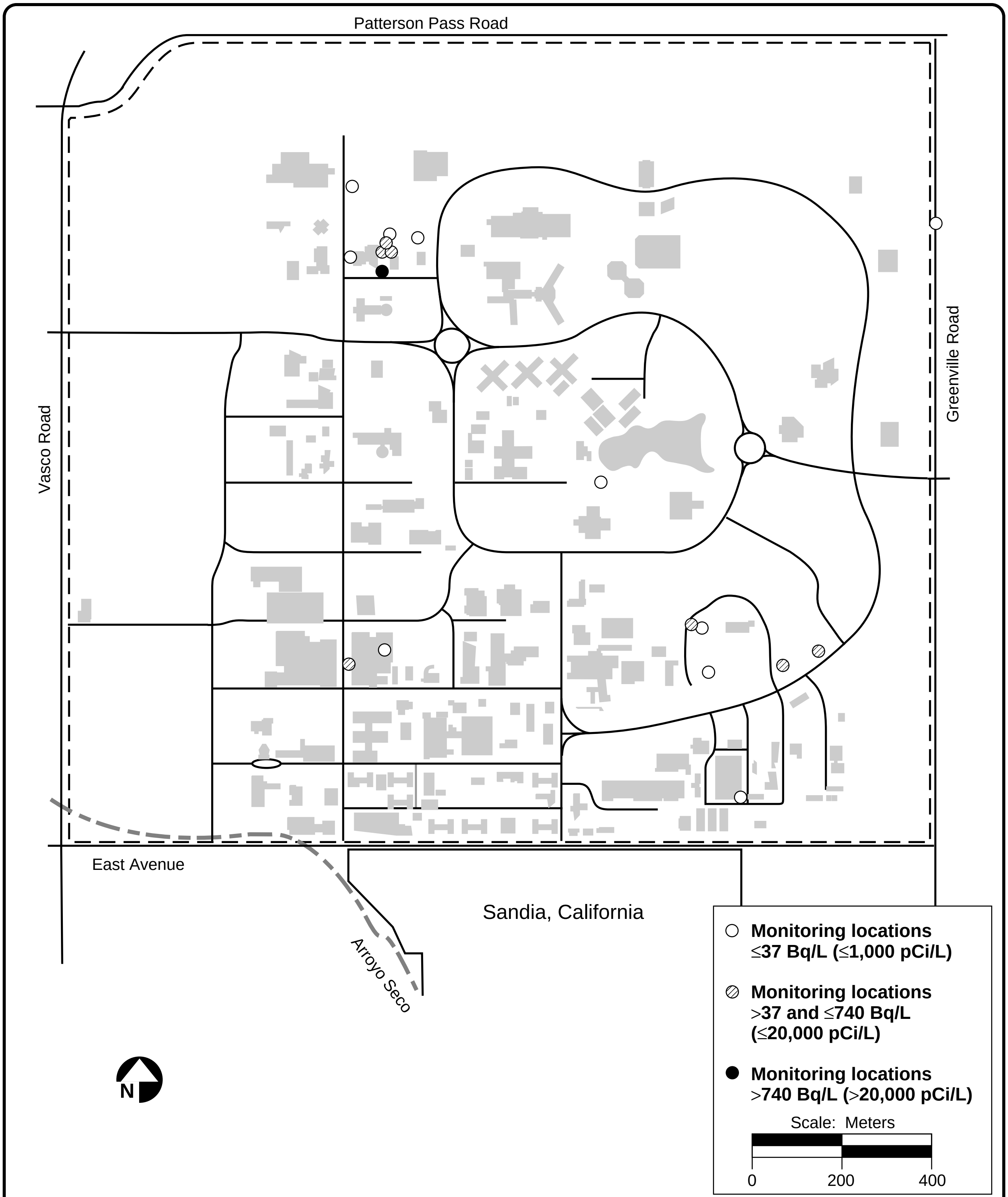

Figure 8-4. Ground water monitoring locations with tritium concentrations exceeding 37 Bq/L (1,000 pCi/L) at LLNL, 1994.

Site 300

Site 300 is also on the EPA National Priority List for sites requiring environmental restoration in accordance with CERCLA. Extensive investigations have been performed to identify and delineate contamination from past practices that has affected or could affect the soil, rock, and ground water underlying LLNL Site 300. Detailed descriptions of these activities and findings are available in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Final SWRI report; Webster-Scholten 1994). The remediation work at Site 300 has not reached the same stage as that at the Livermore site so some areas of possible contamination are still under investigation. (Chapter 2 gives further information on CERCLA remediation activities at Site 300.)

VOCs, primarily TCE, have been detected in the ground water and unsaturated sediments at Site 300. The main areas of concern are predominantly in the southeast portion of the site (**Figure 8-5**). Contaminants in ground water have extended off site from the General Services Area (GSA), which houses the administrative buildings, crafts and mechanical shops, fuel and vehicle repair shops, cafeteria, and main parking. VOCs in excess of the MCLs for TCE and PCE have been identified in the shallow ground water beneath the GSA at two locations: (1) two small plumes occur in the central area, and (2) one plume occurs in the eastern area and the gravels of Corral Hollow Creek, a seasonal arroyo running along the southern border of Site 300. TCE is also present in the Building 833 and Building 834 areas, the HE Process Area, and downgradient of closed landfill Pit 6. Minor detections of TCE have been seen in the East and West Firing Areas (in wells downgradient from closed Pit 7 and the Building 801 / Pit 8 area).

Freon-113 (1,1,2-trichloro-1,2,2-trifluoroethane) has been detected in wells downgradient from the closed Advanced Test Accelerator where Freon-113 was spilled to ground in the past. This is discussed further in Chapter 7 on Routine Ground Water Monitoring.

Discharges of rinse water from buildings within the HE Process Area were historically disposed of in unlined lagoons near the buildings. LLNL no longer uses the lagoons, and they have been closed and capped. However, high-explosive compounds and metals have been detected in the unsaturated sediments beneath some of the lagoons. High-explosive compounds and TCE have been detected in ground water within two perched water-bearing zones beneath the HE Process Area.

Tritium has been identified in ground water from three release sites in the northern portion of Site 300: Pit 3, Pit 5, and the Building 850 firing table. These plumes of tritium in ground water occur in the northern West Firing Area, in Doall Ravine, and in Elk Ravine in the East Firing Area.

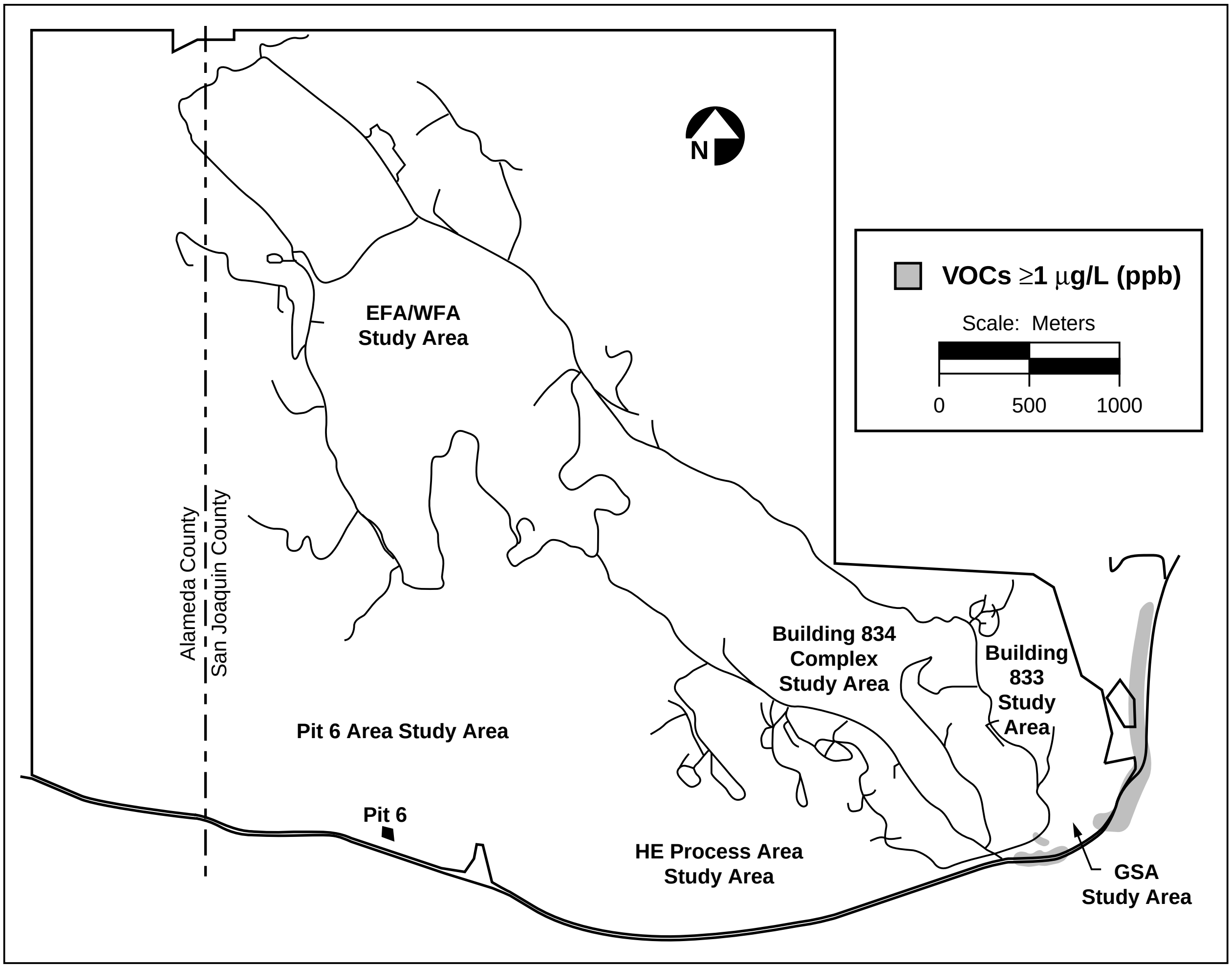

Figure 8-5. Distribution of VOCs in ground water at the General Services Area, Site 300.

The tritium from Pit 3 was released into the ground water when abnormally high water levels flooded landfills; direct infiltration may also have occurred. Tritium was released from the Building 850 firing table due to percolation of rainwater and dust suppression water through the ground surface of the table to ground water.

The ratio of the isotopes ^{235}U to ^{238}U found in nature is about 0.007. The by-product of the enrichment process of ^{235}U is depleted uranium—uranium with a lower proportion of ^{235}U and a mass ratio of less than 0.065. Depleted uranium has been detected in a number of wells downgradient of Pit 7, Pit 5, and Building 850—the three release sites of depleted uranium at Site 300. Studies have determined its extent in soil, rock, and ground water; it is less extensive than tritium. (See Chapter 7 for more detail.)

Results from monitoring wells surrounding Pits 1 and 7 have shown statistically significant evidence of release of some constituents of concern and possible changes in ground water quality. LLNL has reported data for ^{235}U and specific conductivity for Pit 1; and barium, tritium, ^{234}U, ^{235}U, ^{238}U, specific conductivity, pH, and lead for Pit 7. LLNL is required to report "statistically significant evidence of release" based on a comparison of upgradient and downgradient well chemical results and historical monitoring data. LLNL will perform further investigations under CERCLA to determine if the results indicate releases from the pits. The capping of the pits, completed in 1992, eliminates infiltration from the surface, thereby diminishing the rate of potential release of any material from the pits. (See Chapter 7 for further information on Site 300 ground water.)

Waste Minimization/ Pollution Prevention Activities

LLNL beneficially reuses excess construction soils on site if they do not pose a potential threat to beneficial uses of ground water supplies as defined by the local California RWQCB. At a CERCLA site such as LLNL, regulatory agencies usually require that the cleanup level for contaminants be background. The background level for synthetic VOCs, which are the primary contaminants at LLNL, is no contamination (zero concentration). As a result, LLNL selected an alternative method to allow reuse of soils with minimal levels of VOCs. The Designated Level Methodology (DLM), developed by Jon Marshack (Marshack 1991) of the Central Valley was approved for use by both the Central Valley and the San Francisco Bay RWQCB.

We also developed *de minimis* concentrations for VOC-contaminated soils based on the DLM (Isherwood 1994) that have formally been approved by the San Francisco Bay RWQCB for use at the Livermore site. Any soils with VOC contamination below these *de minimis* concentrations can now be reused at the Livermore site. The approval of these levels for VOCs will eliminate the need to landfill most construction soils that could be reused on site. This also ensures that LLNL construction activities add no unacceptable pollution to the ground water beneath the site. *De minimis* concentrations for VOC-contaminated soils have also been developed for Site 300 and submitted to the Central Valley RWQCB (Isherwood 1993); formal approval for use of these concentrations at Site 300 has not yet been received.

The next major project is to update natural background concentrations for trace metals in soils. This work is under way and should be completed in time to report in the *Environmental Report for 1995*.

Remediation Activities

CERCLA and other remediation activities—including the Tank Upgrade Project, the Sanitary Sewer Rehabilitation Project, and the Building Drain Investigation—are discussed below.

CERCLA

Livermore Site

An extensive investigation of the remediation options for the contaminated areas discussed above is summarized in the *CERCLA Feasibility Study for Lawrence Livermore National Laboratory Livermore Site* (Isherwood et al. 1990). The *Record of Decision for Lawrence Livermore National Laboratory Livermore Site* (ROD; Ziagos 1992) documents the remedial options selected for implementation. The selected remedies for ground water contamination involve pumping the ground water for surface treatment by a combination of ultraviolet-light hydrogen peroxide, air stripping, and granulated activated carbon. The selected remedies for contaminants in the unsaturated zone are vacuum-induced venting with surface treatment of the vapors by catalytic oxidation or activated-carbon filtration. The goal of the remedial action is to clean the ground water to the levels specified in the applicable, relevant, and appropriate requirements developed for this project and outlined in the ROD. A description of the remediation efforts during 1994 can be found in Chapter 2.

Site 300

The investigations and preparations for remediation at Site 300 have not progressed as far as those at the Livermore site. The Final SWRI report (Webster-Scholten 1994) was accepted by the regulators. This report compiles all ground water and soil investigation information for Site 300 and contains an assessment of the potential human health and ecological hazards or risks resulting from contamination of soil, sediment, and ground water. Feasibility studies are being prepared for the individual study areas where an unacceptable risk or hazard exists. During 1994, LLNL submitted the *Final Feasibility Study Report for the Building 834 Operable Unit Lawrence Livermore National Laboratory Site 300* (Landgraf et al. 1994), the *Final Feasibility Study Report for the Pit 6 Operable Unit* (Devany et al. 1994), and the *Proposed Plan for Remediation of the Lawrence Livermore National Laboratory Site 300 Building 834 Area Final Draft* (Landgraf et al. 1994) to the regulatory agencies. Current milestone dates for Final Feasibility Study reports are: GSA on May 1, 1995; HE Process Area on December 1, 1995; and Building 850/Pits 3 and 5 on February 15, 1996. A description of the remediation efforts in 1994 can be found in Chapter 2. LLNL, DOE, EPA, DTSC, and the Central Valley RWQCB are at present working to reengineer the CERCLA process to speed up cleanup at portions of Site 300 requiring it.

LLNL properly sealed and abandoned water-supply Well 1 at Site 300. This well was screened across several water-bearing zones that contained elevated tritium activities and, therefore, had the potential to cross-contaminate the aquifers.

Other Remedial Programs

Leaking underground and aboveground tanks, transformers, sanitary sewer pipes, building drain pipes, dry wells, and cooling tower discharges to ground can potentially supply significant quantities of contaminants to the soils and to the ground water. The projects and studies described below are LLNL's 1994 efforts to eliminate or minimize discharges that could adversely impact ground water and/or surface water supplies.

Tank Upgrade Project

The Tank Upgrade Project has included the closure and accompanying soil cleanup of 27 petroleum product underground storage tank (UST) systems with minor to moderate amounts of vadose zone contamination in their immediate vicinity. The suspected cause of contamination in the majority of these tank systems was overspill during filling operations. A total of 74 USTs and 48 above-ground or on-ground storage tanks (whose contents are hazardous product and hazardous/nonhazardous waste) will be closed, replaced, or upgraded as part of this project. Approximately 36 pieces of oil-containing equipment (transformers and sectional switches) will also be upgraded with secondary containment, accompanied by appropriate soil cleanup. As of December 1994, construction was completed for 56 tanks, construction was in progress for 43 tanks, design was completed for three tanks not yet under construction, design was in progress for 52 tanks, and four systems remain to be designed.

Closure and corrective action reports were submitted to San Joaquin County in 1994 on the removal of underground fuel supply tanks at several buildings at Site 300. Seventeen underground and one aboveground tank systems were closed and cleaned up (as required) in an earlier Tank Systems Upgrade Project. (See Chapter 2 for further information.)

Sanitary Sewer Rehabilitation Project

The objective of the Sanitary Sewer Rehabilitation Project is to investigate the condition of, and rehabilitate, the sanitary sewer system at the Livermore site. Over 9,000 meters of sewer line were examined to identify areas where lines were off-set, joints were separated, or a portion of a line was either punctured or had collapsed. The major line breaks and disruptions have been repaired by excavation and pipe replacement. Smaller problems (e.g., line off-sets and cracks) were identified in sufficient numbers to determine that *in situ* lining of over 6,000 meters of piping in the system would be the most cost-effective repair. This lining effort has been completed and will reduce, to an acceptable level, exfiltration from the sewer pipes into the surrounding sediments and, possibly, into the ground water. It will also reduce infiltration of rain water into the sewerage system.

Building Drain Investigation

The Building Drain Investigation, completed in 1992, identified deficiencies in wastewater discharge systems that must be repaired or permitted. If, after examination of the process and sampling and analysis, the discharger did not have a significant impact to the environment, LLNL applied for permits to continue the discharge. Examples of this type of discharge are water from testing of emergency showers and eye-washes and condensate from air conditioners. LLNL is in the process of removing or rerouting the discharge to the sanitary sewer or a retention tank in cases where there may be a significant impact on the environment, including the possibility of ground water contamination.

LLNL submitted a technical report to amend an existing National Pollutant Discharge Elimination System (NPDES) permit at Site 300 to include the non-storm water discharges not covered by another permit on August 1, 1994. A NPDES permit application was submitted to the San Francisco Bay RWQCB on March 23, 1995.

Once the respective regional boards act on the submitted information, LLNL will be required to certify that all discharges are in accordance with environmental regulations. The elimination of discharges that release industrial wastewater to ground will reduce the possibility that contaminants in the wastewater could reach the ground water. Permits issued by the regional boards should establish effluent limits and operating conditions that will protect surface and ground water quality.

In the past two years, LLNL has completed extensive investigations of the sanitary sewer system at the Livermore site and of the building drain systems at both sites. As might be expected at a site with most of its infrastructure over 30 years old, closed-circuit television testing revealed cracks, breaks, and off-set joints in the sanitary sewer system. Exfiltration could have taken place at each of these locations. Repairs were prioritized based on an evaluation and ranking of the problems by an outside contractor. The worst portions of the system have been repaired, and much of the system has been lined to reduce leakage from it. When repairs required excavation, soil samples were taken and analyzed to determine if exfiltration released contaminants into the soil. When necessary, soil from the excavations was removed and disposed of at a properly certified landfill. Further details of this effort are given in the last section of this chapter.

From 1992–1994, LLNL tested over 25,000 drain discharges to determine the location of all nonstorm water discharges to ground or storm sewer systems. The discharge points of the drains were identified through dye testing, smoke testing, and methods as simple as flushing popcorn down the line and watching for its appearance at a downstream manhole. Deficiencies that posed a significant or immediate threat to ground water have been eliminated, and LLNL is in the process of removing or repairing these deficiencies. Eleven discharges that could have affected human health or significantly affected the environment were stopped immediately upon detection. The remaining deficiencies were categorized and identified to facility management and DOE Oakland Operations Office staff. Note that remaining deficiencies do not pose a significant, immediate threat to ground water quality.

Dry Wells and Disposal Lagoons

At Site 300, dry wells and disposal lagoons have been primary points of wastewater release to the environment, including potentially to the ground water. The dry wells and lagoons received wastewater and other liquids from various buildings and test cells by piping or lined trenches. Dry wells were typically filled with gravel and were generally not very deep (often less than 2 meters). Disposal lagoons were often earthen depressions with no metal or concrete sides. Most disposal lagoons were constructed in permeable soil and almost never had standing water. Some disposal lagoons were partially filled with gravel. In a few instances, drainage ditches appear to have been used as disposal lagoons.

Forty-eight dry wells and disposal lagoons were identified in the initial remediation investigation in the 1980s. By 1989, the majority of these dry wells and disposal lagoons were permanently removed from service. Soil and rock samples have been collected and analyzed at most dry wells and disposal lagoons; some dry wells have been excavated. Details of the dry wells and disposal lagoons are presented in the Final SWRI report (Webster-Scholten 1994).

During the recent efforts to repair or permit deficiencies identified by the Building Drain Investigation, approximately 13 dry wells were identified as still being in use. We are working to determine if there are discharges to any of these wells and how to close them. Since wastewaters discharged into these drywells might reach ground water, LLNL is working to discontinue their use, thereby assuring that any constituents that are present cannot reach the ground water.

In the past, landfills were in use at Site 300 to accept debris from high-explosive testing and other experiments. Except for Pits 1 and 7, all the landfills were closed prior to 1980 and did not require closure under RCRA. In 1988, LLNL also ceased operations of these landfill Pits 1 and 7 and began the closure process. Both were capped in 1992, and LLNL began post-closure activities under the submitted post-closure monitoring plan (Rogers/Pacific Corporation 1990). LLNL applied for and received a permit specifying Waste Discharge Requirements (WDR Order No. 93-100) and defining the monitoring and reporting requirements. Monitoring of wells surrounding Pits 1 and 7, under permit WDR Order No. 93-100, has resulted in LLNL reporting statistically significant evidence of release of some constituents of concern, and several monitoring parameters indicate changes in the ground water quality. Further investigations will be completed under CERCLA to determine if the results are due to releases from the pits. It is expected that the capping of the pits, completed in 1992, has eliminated infiltration from the surface, thereby diminishing the rate of potential release of any material from the pits.

Cooling Towers

Twenty-three cooling towers are operated at Site 300 to cool buildings and equipment. Of these, six discharge wastewater to septic tanks. In the past, 17 towers discharged wastewater to on-site surface drainage courses. During the latter part of 1994, LLNL installed engineered percolation pits for 14 of the 23 cooling towers. Construction of all the percolation pits was completed by December 1994. The RWQCB issued a waiver from Waste Discharge Requirements when it was determined that the cooling tower discharges into the percolation pits would not adversely affect the receiving water.

The Central Valley RWQCB issued the new permit expanding the pH range for the remaining cooling towers discharging to surface water drainage courses because of the low threat imposed by the cooling towers on the surface waters. The new permit was issued on May 20, 1994. (For further information on the cooling tower discharges, see Chapter 13.)

Registration of Disposal Systems

In January 1995, LLNL registered 52 subsurface wastewater disposal systems at Site 300, meeting EPA’s definition of Class 5 injection wells under the Safe Drinking Water Act regulations. These disposal systems included: septic systems designed to serve more than 20 people or accepting industrial wastewater, such as boiler blowdown, active and inactive dry wells, the cooling tower percolation pits, and a sewage overflow percolation pond. EPA final permit regulations for Class 5 were expected in March 1995; however, EPA staff note that these final regulations will be indefinitely delayed. This registration is designed to inform EPA of the types of nonhazardous wastewater discharges injected into substrata above drinking water aquifers so that a determination can be made as to the risk of such discharges. EPA may require additional information, establish discharge limitations, or require elimination of discharges that pose a risk to the drinking water aquifers.

8. Ground Water Protection Management Program

Summary

It is LLNL's policy to operate in a manner that does not adversely affect the environment. Past material-handling activities and practices have resulted in ground water contamination. LLNL is working closely with local, state, and federal regulatory agencies, with input from the public, to develop and implement efficient, cost-effective ways to remediate the contamination. LLNL is also looking at its current and future operations to prevent possible negative impacts to ground water. Through ongoing plans, LLNL is working to remove sources of concern and to implement protection against accidental impacts.